

Design of Intelligent Monitoring System for Power Distribution Equipment Based on Cloud Edge Collaborative Computing

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Abstract—With the development of sensor technology, when facing the explosive growth of large power data, the existing data acquisition and monitoring system (SCADA) is increasingly inadequate in data processing ability and lack of intelligence. In this paper, a novel intelligent monitoring system for power distribution equipment based on cloud edge collaborative computing is designed to effectively improve the efficiency and intelligence of mass data processing. At the edge end, an improved intelligent data acquisition device is adopted as the edge computing node, where the original data is collected and uploaded with variable frequency, in order to enhance the value density of data and reduce the network load and cloud load. In addition, data monitoring cloud platform is designed in the cloud, where a data mining model is established by using Apriori frequent item set algorithm, to provide more accurate monitoring and diagnosis services for upper applications, and guide the edge end to conduct intelligent control of devices. The reliability and performance of the designed system are validated by the intelligent monitoring project of box substation power distribution equipment.

Keywords—Component; Edge Computing; Cloud Edge Collaboration Computing; Fault Diagnosis

I. INTRODUCTION

At present, the monitoring of distribution equipment mainly relies on SCADA (Supervisor Control and Data Acquisition). Its main function is to collect field data, realize comprehensive and real-time monitoring of equipment status, and provide data services for equipment monitoring, fault judgment and scheduling[1]. However, with the continuous development of sensors, Internet of things and cloud computing technology, the original data from equipment monitoring become more and more frequent and less valuable. These data are continuously transmitted to cloud

servers through the network, consuming a large amount of network and storage resources. At the same time, the computing resources of cloud server are mostly consumed in the fixed threshold comparison of massive original data, while the more valuable abnormal data are not focused on, leading to the failure to find and deal with abnormal events of devices timely [2].

Over the years, scholars at home and abroad have paid extensive attention to how to achieve effective monitoring of distribution systems. Gong Gangjun[3] et al. analyzed the similarities and fusion ways between edge computing technology and information physical system (CPS) of active distribution network, and proposed a PTN physical architecture model of active distribution network based on edge computing. Dao[4] et al. proposed a new collaborative analysis method for SCADA data, which is used for state monitoring and fault diagnosis of wind turbines. Alves[5] et al. proposed a method based on preprocessing algorithm to process massive multidimensional data in power SCADA system. Sharma[6] et al. proposed a framework for coordinated processing between edge and cloud computing. The framework can use cloud-centric knowledge base and historical data to guide edge computing units in computing, so as to meet various performance requirements of heterogeneous wireless IoT networks. Maduako[7] et al. used edge nodes for data preprocessing to solve the blocking problem when uploading large amounts of data to the cloud. Confais[8] et al. proposed a fog/edge computing infrastructure to solve the data latency problem of several application development.

As an extension and upgrade of cloud computing, the existing research results show that Cloud-Edge collaborative computing has a significant effect on big data processing capacity and processing efficiency. However, relevant researches have not yet introduced Cloud-Edge collaborative

computing into intelligent monitoring of devices, especially SCADA system. Therefore, in view of the problems existing in the current power equipment monitoring system, such as heavy network load, high delay, inadequate detection of abnormal state of equipment and slow response speed, we design an intelligent monitoring system for power distribution equipment based on Cloud-Edge collaborative computing, which divides and cooperates SCADA business into the Edge and Cloud.

II. FRAMEWORK OF INTELLIGENT MONITORING SYSTEM FOR EQUIPMENT BASED ON CLOUD EDGE COOPERATIVE COMPUTING

Comparing with the remote computing mode of cloud computing, edge computing refers to the technology of localized data acquisition, instant computing, real-time online diagnosis, timely response and precise control at the data source. Edge computing integrates computing, storage and transmission into the interior of edge devices, so that data can be processed timely and effectively at the source without being transferred to the cloud, which will greatly improve the processing efficiency and value density of data and reduce the load of cloud data processing. Edge computing and cloud computing are synergistic and complementary: As a collection and pre-processing unit of high-value data in the cloud, edge computing can support cloud applications better because it is closer to the device execution unit; on the contrary, through big data mining and analysis, cloud computing sends optimized models or rules to edge nodes to guide them to collect and process data better. Cloud-Edge collaborative computing links device-side

acquisition, edge computing and cloud computing on the Internet, which establishes a computing framework from device-side to edge and then to cloud, and builds an IoT core computing capability.

The system adopts "edge-cloud-application" three-layer deployment architecture. "Edge" is responsible for data ubiquitous perception, accessing various types of parameters data from sensors or instruments, extracting the valuable data and uploading it to the cloud after automatic interpretation; In the cloud, the results of data mining are pushed to the upper application software, and the results of data learning are downloaded to the edge nodes to control them self independently and intelligently. The network topology of the designed system is shown in Figure 1.

Compared with the traditional intelligent monitoring system of equipment, the system we designed needs two actions. First, a data monitoring platform needs to be built in the cloud, and then data acquisition devices are upgraded to edge computing nodes, which have data computing, storage and communication capabilities.

A data mining model is built in the cloud platform. Apriori algorithm is used to analyze the historical data of monitoring parameters in previous equipment failures, obtain frequent item sets of parameters exceeding the limit, and mine the correlation between equipment failures and parameters exceeding the limit. Key combinations of parameters that can determine whether the equipment fails or not are mined, which will be focused on by increasing the frequency of data acquisition. The collaboration diagram of "Cloud-Edge-Terminal" is shown in Figure 2.

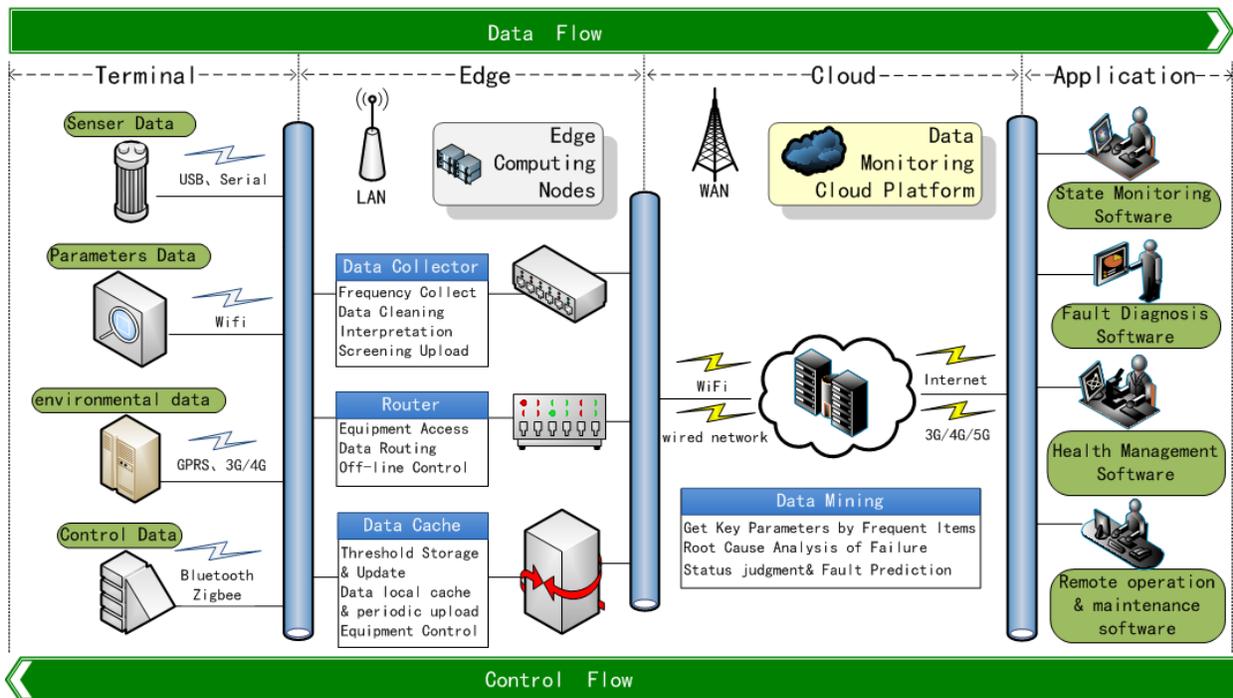


Figure 1. Network topology diagram of designed system

The design of edge computing nodes plays an important role in the system, including automatic data interpretation and data acquisition and uploading of variable frequency. The threshold criterion of monitoring parameters is stored in the edge computing node. Firstly, the real-time data is automatically interpreted according to the threshold value,

which are stored in the edge computing nodes, and then the collection and upload frequency is adjusted by combining the importance of parameters and the overrun level. The aim is to reduce the amount of transmission of low value normal data and ensure the amount of abnormal data with high value.

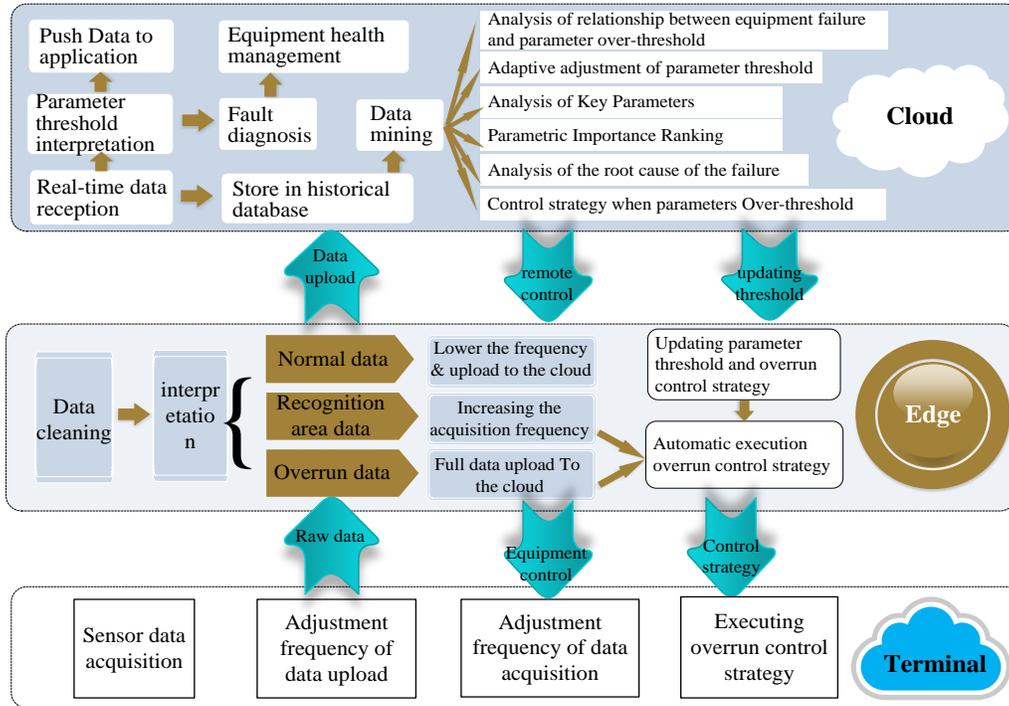


Figure 2. Collaboration Diagram of "Cloud-Edge-Terminal"

III. SYSTEM IMPLEMENTATION

In order to verify the validity and feasibility of the system designed above, a SCADA system based on Cloud-Edge collaborative computing is implemented, which meets the need of intelligent monitoring of distribution equipment from a box-type substation manufacturer. According to the requirement of edge computing node, the ARM board and data acquisition box as shown in Figure 3 are designed, which integrate communication, data processing and storage modules. Tencent cloud server is selected as data monitoring cloud platform, HBase is used as database, and Storm stream is used to process real-time data uploaded by edge nodes. In the application layer, the operation and maintenance management platform is designed with C # language, and the modules of data monitoring, alarm management, fault diagnosis and remote control are developed. Intelligent monitoring services such as operation condition monitoring and abnormal working condition alarm for box substation are realized. The main interface is shown in Figure 4.

After the stable operation of the new system, four indicators are selected to compare with the original system, which are the total monitoring data per unit time, data delay, fault alarm amount and fault judgment accuracy rate. The results are shown in Figure 5 below.

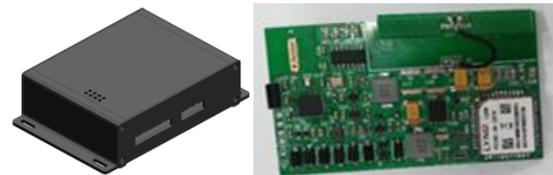


Figure 3. Data acquisition box and ARM board as edge computing node



Figure 4. Software interface of power equipment operation and maintenance management platform

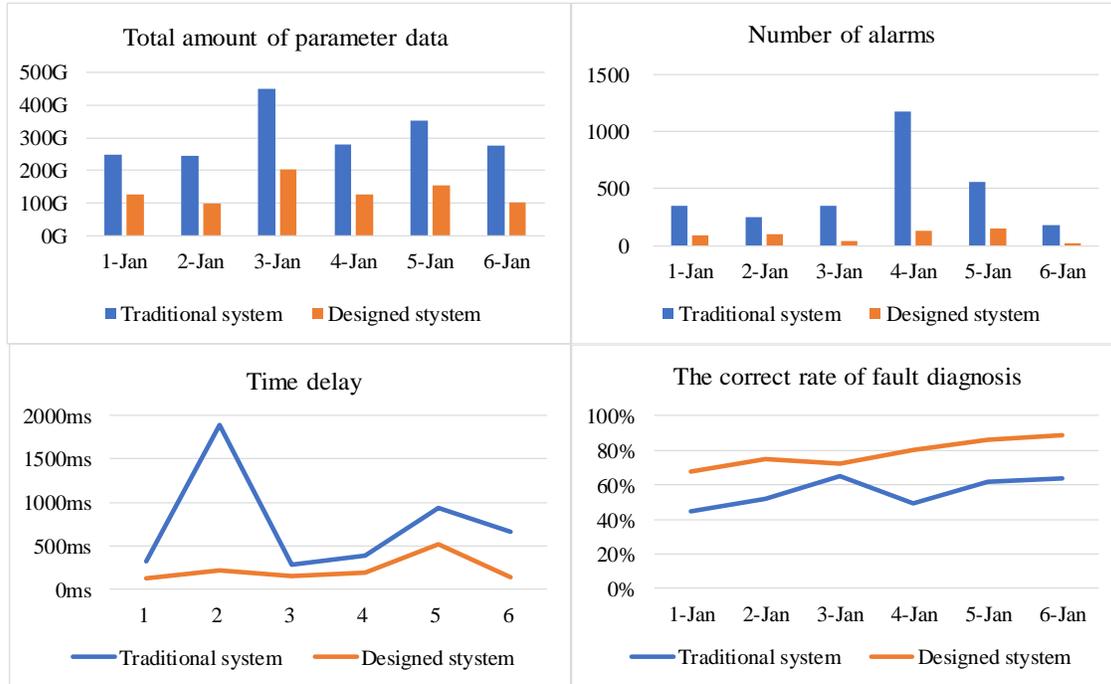


Figure 5. Comparisons of system performance between cloud edge collaboration architecture and traditional architecture

IV. CONCLUSION

An intelligent monitoring system for power equipment, using “Edge-Cloud-Application” Architecture, is designed based on Cloud-Edge collaborative computing. Computing power is given to the edge equipment, which helps to pick out important data from a large number of real-time data and upload them to the cloud at different frequencies. At the same time, data mining is carried out in the cloud platform to provide precise and intelligent services for upper applications such as on-line condition monitoring, fault diagnosis and health management of equipment. This system uses the powerful data analysis ability of cloud platform to mining the historical data of equipment failure, and jointly provides on-line condition monitoring, equipment fault diagnosis, equipment health management and so on. Finally, a system is developed based on a specific example of the enterprise, which proves that the system designed in this paper can not only monitor the status of equipment effectively, but also greatly reduce the total amount of data, reduce the data delay, control the number of equipment alarms effectively, improve the reliability of alarms and the accuracy of equipment fault diagnosis.

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